

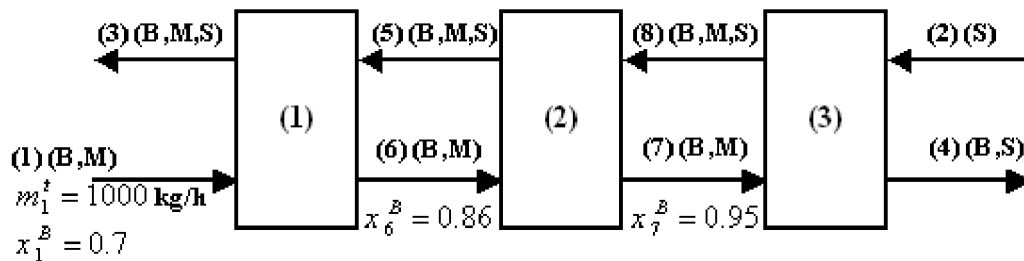
Example 1 (Dr. Kamil's Book, page 75)

A three-stage solvent extraction unit is used to extract benzene (B) from a mixture containing it with methanol (M) by sulfur dioxide (S) as shown in the diagram below.

Additional data:

- 1- 92% of benzene entering unit (1) is extracted in the unit.
- 2- 80% of benzene entering unit (2) is extracted in the unit.
- 3- $\frac{m_2^S}{m_1^t} = 3$;
- 4- $\frac{m_4^S}{m_4^t} = 1/6$;
- 5- $\frac{m_3^B}{m_3^M} = 0.25$

Calculate the missing flow rates.



Solution

- 1- 5 Relations:

$$1- \frac{m_6^B}{(m_1^B + m_5^B)} = 0.92$$

$$2- \frac{m_7^B}{(m_6^B + m_8^B)} = 0.8$$

$$3- \frac{m_2^S}{m_1^t} = 3$$

$$4- \frac{m_4^S}{m_4^t} = 1/6$$

$$5- \frac{m_3^B}{m_3^M} = 0.25$$

2- Degree of Freedom analysis (INDEPENDENT)

Item	Unit (1) streams: 1,3,5,6	Unit (2) streams: 5,6,7,8	Unit (3) streams: 7,8,2,4	Overall streams: 1,3,2,4	Process streams: All
Unknowns	10 B1,M1, B3,M3,S3, B5,M5,S5, B6,M6)	10 (B5,M5,S5, B6,M6, B7,M7, B8,M8,S8)	8 B7,M7, B8,M8,S8, S2, B4,S4	8 B1,M1, B3,M3,S3, S2, B4,M4	18 B1,M1, B3,M3,S3, B6,M6, B5,M5,S5, B7,M7, B8,M8,S8, B4,S4, S2
Information					
M.B.E.	3 B,M,S	3 B,M,S	3 B,M,S	3 B,M,S	9 =3+3+3
Flow rates	1 ml	0	0	1 ml	1 ml
Compositions	2 x_1^B, x_6^B	2 x_6^B, x_7^B	1 x_7^B	1 x_1^B	3 x_1^B, x_6^B, x_7^B
Relations	2 $\frac{m_6^B}{(m_1^B + m_5^B)} = 0.92$ $\frac{m_3^B}{m_3^M} = 0.25$	1 $\frac{m_7^B}{(m_6^B + m_8^B)} = 0.8$	1 $\frac{m_4^S}{m_4^I} = 1/6$	3 $\frac{m_4^S}{m_4^I} = 1/6$ $\frac{m_3^B}{m_3^M} = 0.25$ $\frac{m_2^S}{m_1^I} = 3$	5 All
Total Info.	8	6	5	8	18
I - U	8-10=-2	6-10=-4	5-8=-3	8-8=0	18-18=0
				solvable	solvable

EZSOLVE PROGRAM

// MATERIAL BALANCES (=9)

// UNIT 1

$$B1 + B5 = B3 + B6$$

$$M1 + M5 = M3 + M6$$

$$S5 = S3$$

// UNIT 2

$$B6 + B8 = B5 + B7$$

$$M6 + M8 = M5 + M7$$

$$S8 = S5$$

// UNIT 3

$$B7 = B8 + B4$$

$$M7 = M8$$

$$S2 = S8 + S4$$

// FLOW RATES (=1)

$$B1 + M1 = 1000$$

// COMPOSITIONS (=3)

$$B1/M1 = 70/30$$

$$B6/M6 = 86/14$$

$$B7/M7 = 95/5$$

// RELATIONS (=5)

$$B6/(B1+B5) = 0.92$$

$$B7/(B6+B8) = 0.8$$

$$S2/(B1+M1) = 3$$

$$S4/(B4+S4) = 1/6$$

$$B3/M3 = 0.25$$

SOLUTION

B1	B3	B4	B5	B6	B7	B8
700	75	625	237.5	862.5	950	325
M1	M3	M5	M6	M7	M8	
300	300	140.407	140.407	50	50	
S2	S3	S4	S5	S8		
3000	2875	125	2875	2875		